Status of ESA's Mars Activities

MEPAG meeting
Washington DC, 13-14 May 2014

Rolf de Groot
European Space Agency
Robotic Exploration Coordination Office
Science and Robotic Exploration Directorate

Mars Exploration at ESA

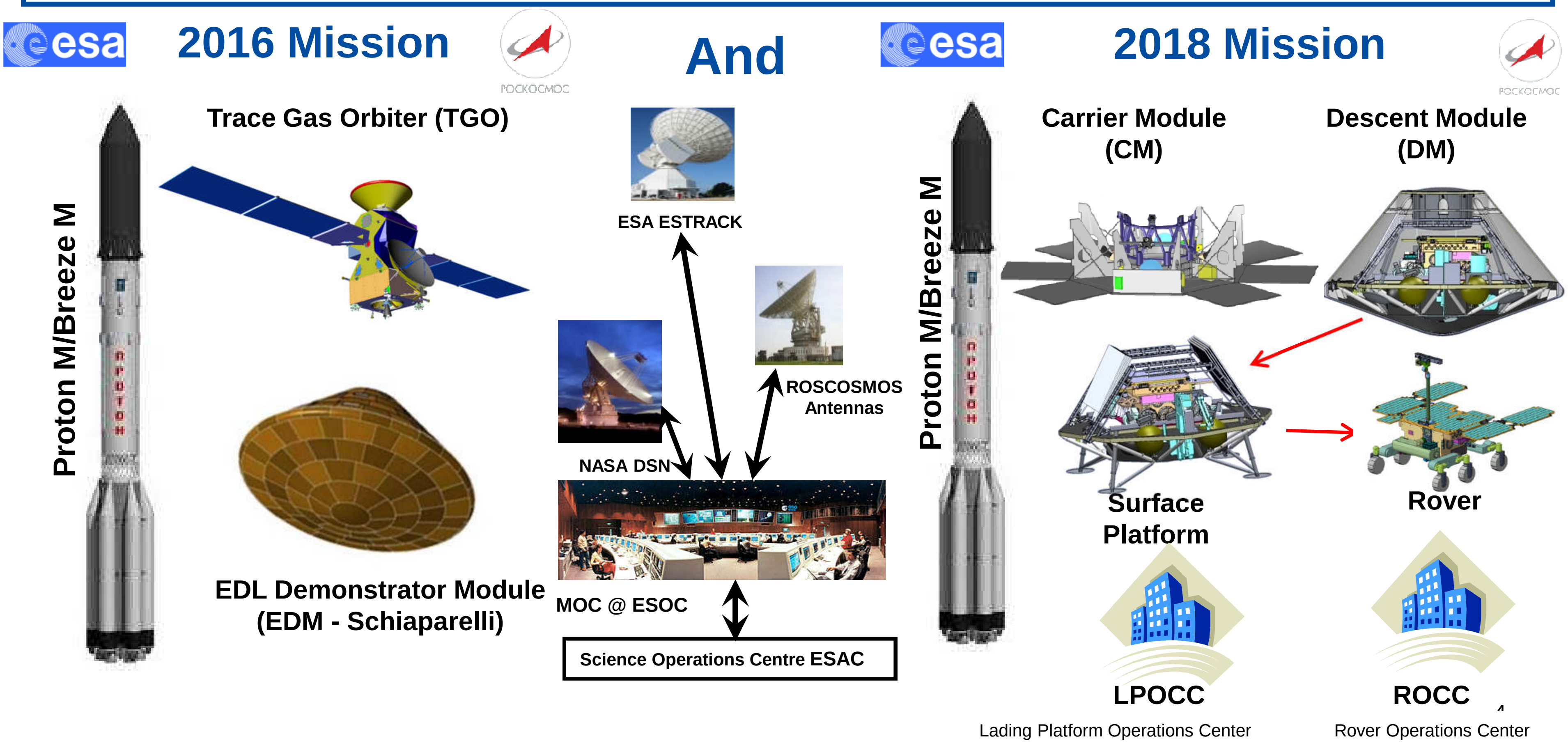
Mars Express Mission: Status and near future milestones

- Status:
  - Spacecraft and payload status: very good
  - Fuel estimates enough for a few more years.
  - Mission extension: until end of 2016, 2017-2018 proposal Q4 2014.
  - 29 December 2013: closest ever flyby of Phobos (~ 45 km).
- Near future milestones
  - 19 October 2014: Siding Spring comet flyby (distance ~ 135,000 km)
  - October 2014 onwards: coordinated measurements with the NASA MAVEN mission. Scientific objective: study of the plasma environment and atmospheric escape.
  - October 2016: Mars Express relays data from the ExoMars entry and descent module

ExoMars Programme

Two missions launched in 2016 and 2018, respectively

- The 2016 flight segment consists of a **Trace Gas Orbiter (TGO)** and an **EDL Demonstrator Module (EDM) - Schiaparelli**
- The 2018 flight segment consists of a **Carrier Module (CM)** and a **Descent Module (DM)** with a **Rover** and a stationary **Surface Platform**



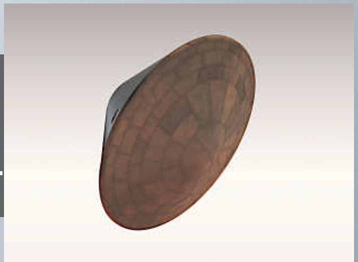
2016 Mission Objectives

EXOMARS

2016

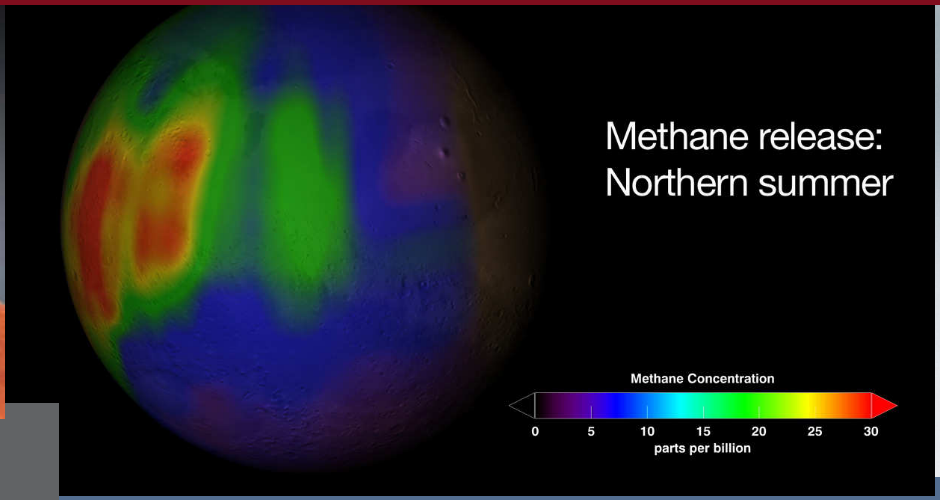
TECHNOLOGY OBJECTIVE

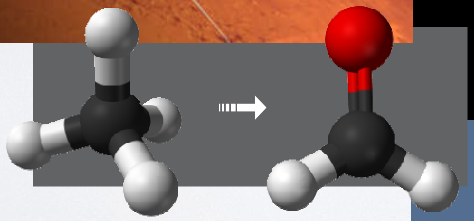
- Entry, Descent, and Landing (EDL) of a payload on the surface of Mars.



SCIENTIFIC OBJECTIVE

- To study Martian atmospheric trace gases and their sources.
- To conduct surface environment measurements.





- Provide data relay services for landed missions until 2022.

2018 Mission Objectives

E X O M A R S

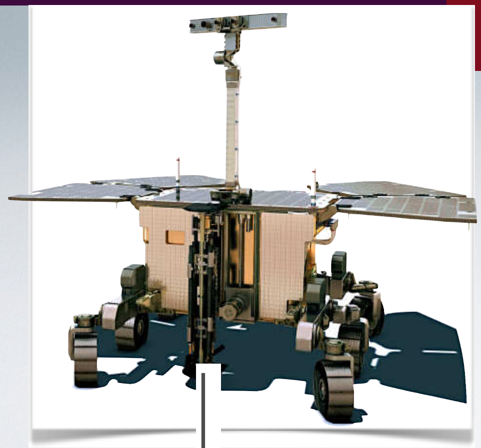
TECHNOLOGY OBJECTIVES

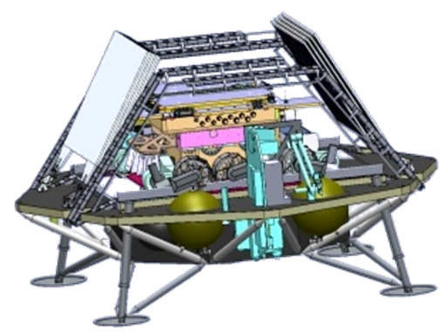
- Surface mobility with a rover (having several kilometres range);
- Access to the subsurface to acquire samples (with a drill, down to 2-m depth);
- Sample acquisition, preparation, distribution, and analysis.
- Qualification of Russian ground-based means for deep-space communication
- Adaptation of Russian on-board computer for deep space missions and ExoMars landed operations
- Development and qualification of throttleable braking engines for prospective planetary landing missions

2018

SCIENTIFIC OBJECTIVES

- To search for signs of past and present life on Mars;
- To characterise the water/subsurface environment as a function of depth in the shallow subsurface.
- To characterise the surface environment.





Current status

ExoMars programmatic status

- ESA – Roscosmos ExoMars agreement in force (14 March 2013)
- ESA – NASA MoU on ExoMars 2016 in force (29 April 2014)
- Revised Science Management Plan approved (February 2014)

2016 ExoMars Mission (TGO and EDM)

- Contract signed with Industry for full development, launch and operations
- Operations and science ground segment in development
- System Critical Design Review (S-CDR) board meeting on 18-4-2014 concluded no show stoppers but requested further reporting on some issues
- 2016 mission on schedule with limited margins
- Effect of US State Department block on Export Licences still tbd

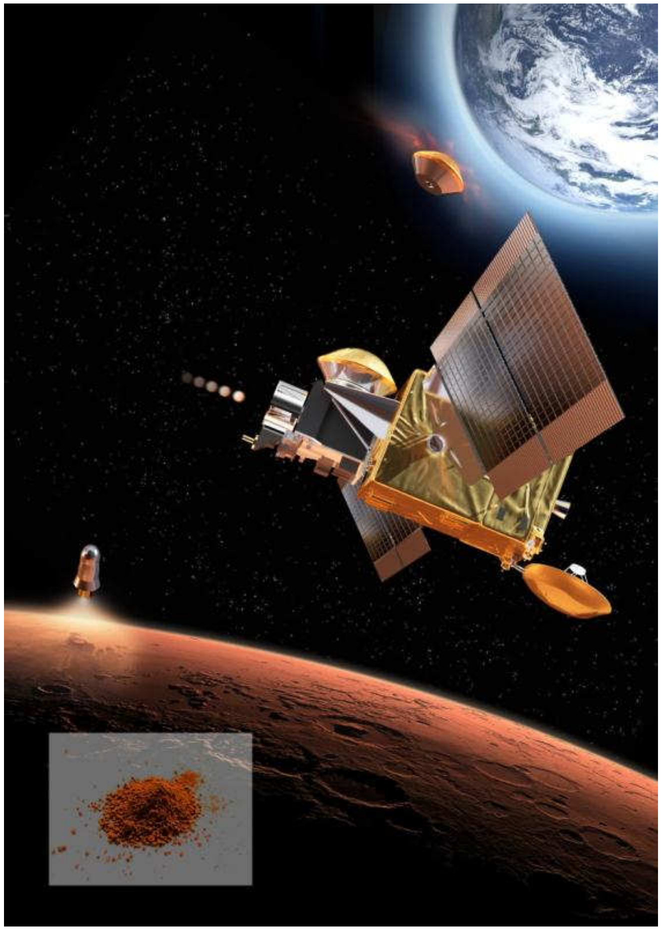
2018 ExoMars Mission (CM, DM, Rover)

- The 2018 mission is in Phase B (CM, DM), while the Rover is in Advanced CD
- System Requirements Review (SRR) close-out on 17 December 2013
- Landing Site Selection process kicked-off in December 2013 (*see JV presentation*)
- AO for Surface Platform instruments in preparation (Q2 2014 tbc)
- Descent Module Design Project Review ongoing (March-June 2014)
- System Preliminary Design Review (S-PDR) in preparation (May-July 2014)
- Full Industrial Proposal expected in Q3 2014

ESA activities for future Mars exploration

The Mars Robotic Exploration Preparation Programme (MREP)

- **Mission studies for post-ExoMars missions**
  - PHOOTPRINT, INSPIRE, MPL-SFR, ..
- **Exploration Technology Development**
  - Mission specific technologies
  - Long-term enabling technologies (Nuclear Power Systems, Advanced Propulsion)
  - General MSR preparatory technology activities (eg. sampling, PP related technologies, sample rendezvous and capture, precision landing, …)
- **MREP phase 2 ongoing, open for new subscriptions at C-MIN 2014**



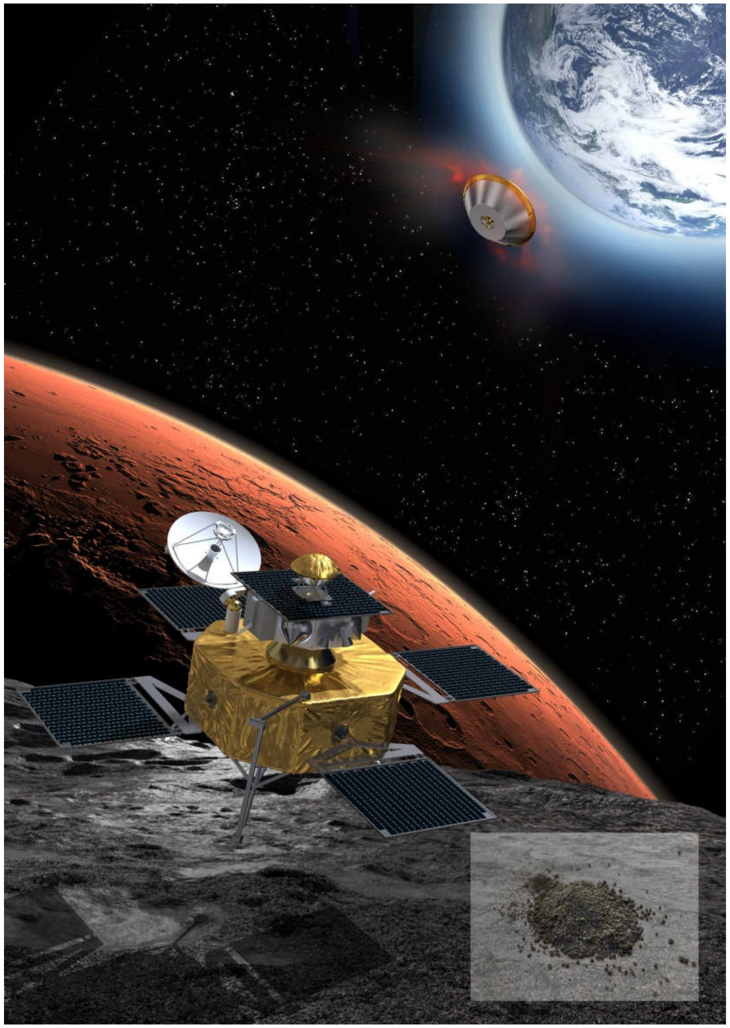
Mars Sample Return: Current developments in ESA

Technology development activities are implemented in ESA Mars Robotic Exploration Preparation Programme (MREP) and focused on specific themes:

- MSR Orbiter, including Orbiting Sample capture and biosealing in orbit, and Earth Return Capsule
- Sample fetch rover: Small rover (100 kg) with high surface mobility
- Precision landing on Mars: development of a capability to deliver 300 kg to Mars surface with a precision better than 10 km
- Sample receiving facility

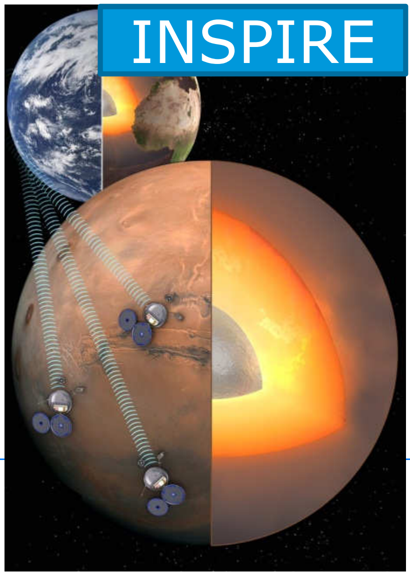
PHOOTPRINT Mars-2024 candidate

- **Return a sample of ~100 g from Phobos**
- **Reference Payload ~35 kg**
  - Cameras, VIS-NIR and Mid-IR spectrometers
  - Heritage from Rosetta, VEX and Bepi-Colombo
- **High and recognised intrinsic science value**
  - Origin and formation of Phobos; Solar System evolution
- **Prepares critical building blocks for MSR**
  - Sampling, transfer and sealing
  - Short range Rendezvous
  - Earth Return Capsule
  - Sample receiving facility
- **Possible scenarios for cooperation with Roscomos identified**
  - CDF study on joint mission on-going April-May 2014
  - Industrial phase A/B1 study in 2014 / 2015
  - Implementation proposal C-MIN 2016 (tbc)



Other candidate missions: INSPIRE and MPL

- Network of 3 surface elements for Mars interior and atmosphere characterisation.
- Timely after InSight and with potential of TGO being available
- Mature Payload, ~ 15 kg
- Seismometer, Mole with Heat Flow and Physical Properties Probe, Meteorological Boom, Radio-Science Package and Camera
- Heritage from ExoMars/Humboldt and Insight developments



- Soyuz launch of a Mars Precision Lander (MPL) + small science rover (10 km landing site accuracy)
- Explore a new region of Mars to investigate the (hydro-)geologic history, and habitability potential, taking benefit of high mobility
- Rover mobility > 170 m/sol capability, 3.5 to 5 hours available to drive per sol. GNC high mobility algorithms developed by MREP
- MSR preparation: MPL could be a segment of MSR Campaign, delivering the sample fetch rover

Back-up slides

Trace Gas Orbiter

EXOMARS

NOMAD

High-resolution occultation and nadir spectrometers

Atmospheric composition (CH_4, O_3, trace species, isotopes) dust, clouds, P&T profiles

UVIS (0.20 – 0.65 µm) $\lambda/\Delta\lambda$ ~250	SO	Limb	Nadir
IR (2.3 – 3.8 µm) $\lambda/\Delta\lambda$ ~10,000	SO	Limb	Nadir
IR (2.3 – 4.3 µm) $\lambda/\Delta\lambda$ ~20,000	SO		

CaSSIS

High-resolution, stereo camera

Mapping of sources
Landing site selection

ACS

Suite of 3 high-resolution spectrometers

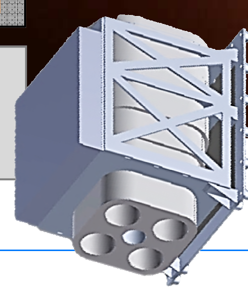
Atmospheric chemistry, aerosols, surface T, structure

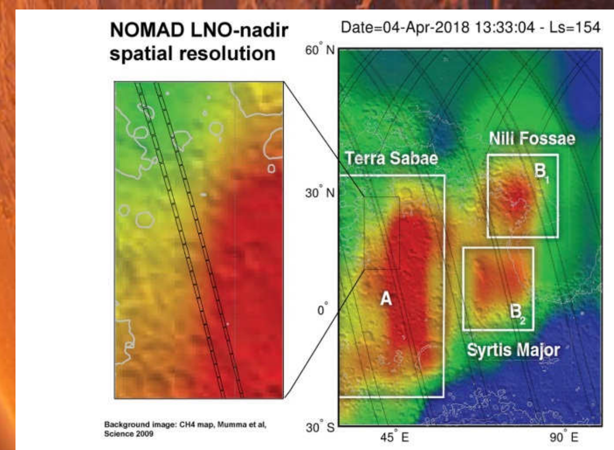
Near IR (0.7 – 1.7 µm) $\lambda/\Delta\lambda$ ~20,000	SO	Limb	Nadir
IR (Fourier, 2 – 25 µm) $\lambda/\Delta\lambda$ ~4000 (SO)/500 (N)	SO		Nadir
Mid IR (2.2 – 4.5 µm) $\lambda/\Delta\lambda$ ~50,000	SO		

FREND

Collimated neutron detector

Mapping of subsurface water
And hydrated minerals





Credit: Kees Veenenbos

Pasteur Payload

EXOMARS

PanCam
Wide-angle stereo camera pair
High-resolution camera

Geological context
Rover traverse planning
Atmospheric studies

WAC: 35° FOV, HRC: 5° FOV

ISEM
IR spectrometer on mast

Bulk mineralogy of outcrops
Target selection

λ = 1.15 – 3.3 µm, 1° FOV

CLUPI
Close-up imager

Geological deposition environment
Microtexture of rocks
Morphological biomarkers

20-µm resolution at 50-cm distance, focus: 20 cm to ∞

WISDOM
Ground-penetrating radar

Mapping of subsurface stratigraphy

3 – 5-m penetration, 2-cm resolution

FREND
Passive neutron detector

Mapping of subsurface
Water and hydrated minerals

Drill + Ma_MISS
IR borehole spectrometer

In-situ mineralogy information

λ = 0.4 – 2.2 µm

Analytical Laboratory Drawer

MicrOmega
VIS + IR Spectrometer

Mineralogical characterization of crushed sample material
Pointing for other instruments

λ = 0.9 – 3.5 µm, 256 x 256, 20-µm/pixel, 500 steps

RLS
Raman spectrometer

Geochemical composition
Detection of organic pigments

spectral shift range 200–3800 cm^{-1}, resolution ≤ 6 cm^{-1}

MOMA
LDMS + Pyr-Dev GCMS

Broad-range organic molecules at high sensitivity (ppb)
Chirality determination

Laser-desorption extraction and mass spectroscopy

Pyrolisis extraction in the presence of derivatisation agents, coupled with chiral gas chromatography, and mass spectroscopy

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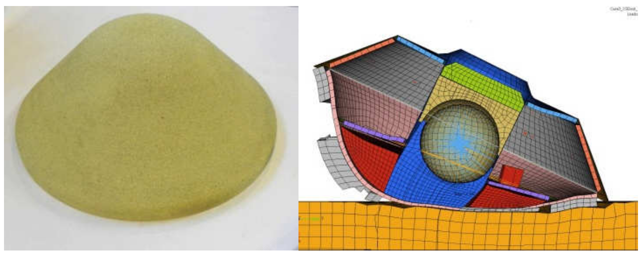
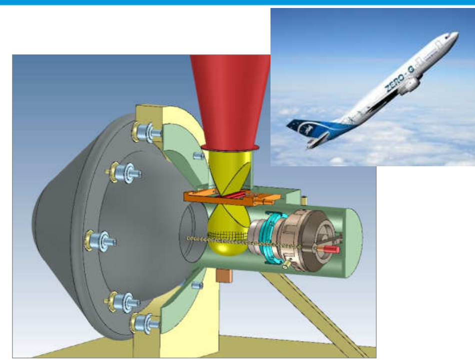
MREP Technology Development Overview

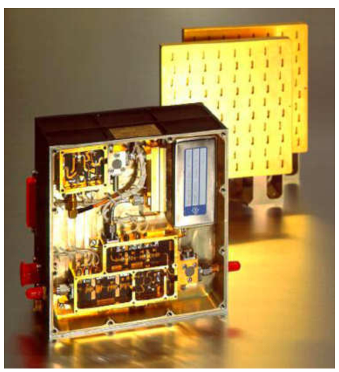


Earth Return Capsule developments

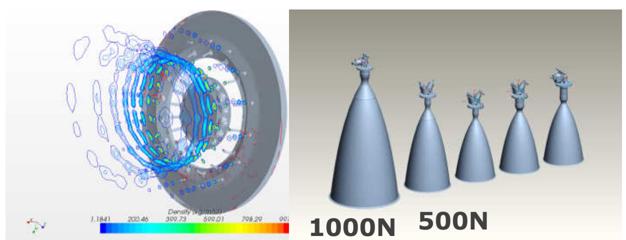


Sample Capture and biosealing in orbit developments

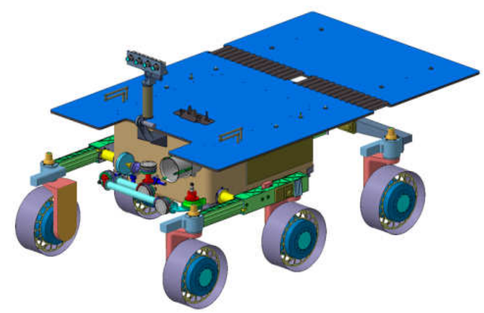
Nuclear Power Sources RHU & RPG , based on Am(241) radioisotope



Precision Landing equipment : Inertial Measurement Unit, altimeter miniaturisation



1 kN bi-liquid engine development for Mars insertion



Sample Fetch Rover and high mobility demonstration